SPECIFICATIONS FOR THE LHC TW PU

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- Introduction
- General LHC (and SPS) Parameters
- Layout and Infrastructure
- Schottky Detector Mech. Specs
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Abstract

- The measurement of the incoherent tunes in the LHC without external excitation of the beam will be performed using a microwave Schottky detector system. This system will be used to monitor the stability of the beam tunes during coast, and identify any drifts of beam parameters which could affect the luminosity. The present specification describes the functional requirements of Schottky detectors based on forward traveling wave couplers. One monitor per plane and per beam will be installed in Point 4 of the LHC. The design and implementation of these monitors and related signal treatment electronics can be part of the US LHC Accelerator Research Program (LARP).

1. Introduction

- The LHC microwave Schottky detectors will be based on the travelling wave system which has been successfully implemented at FNAL for stochastic cooling and incoherent Schottky diagnostics. The advantage of this system is that is gives a high sensitivity even for operation with a small number of bunches. In order to limit the contribution to the impedance of the machine, the operational frequency must be above the coherent bunch spectrum, but below the band overlap frequency of the Schottky signals.
- The mechanical design of this pick-up must be such that it meets the integration constraints imposed by the beam aperture at the pick-up location and the fact that the LHC has 2 adjacent beam pipes.

2. General LHC Parameters (1)

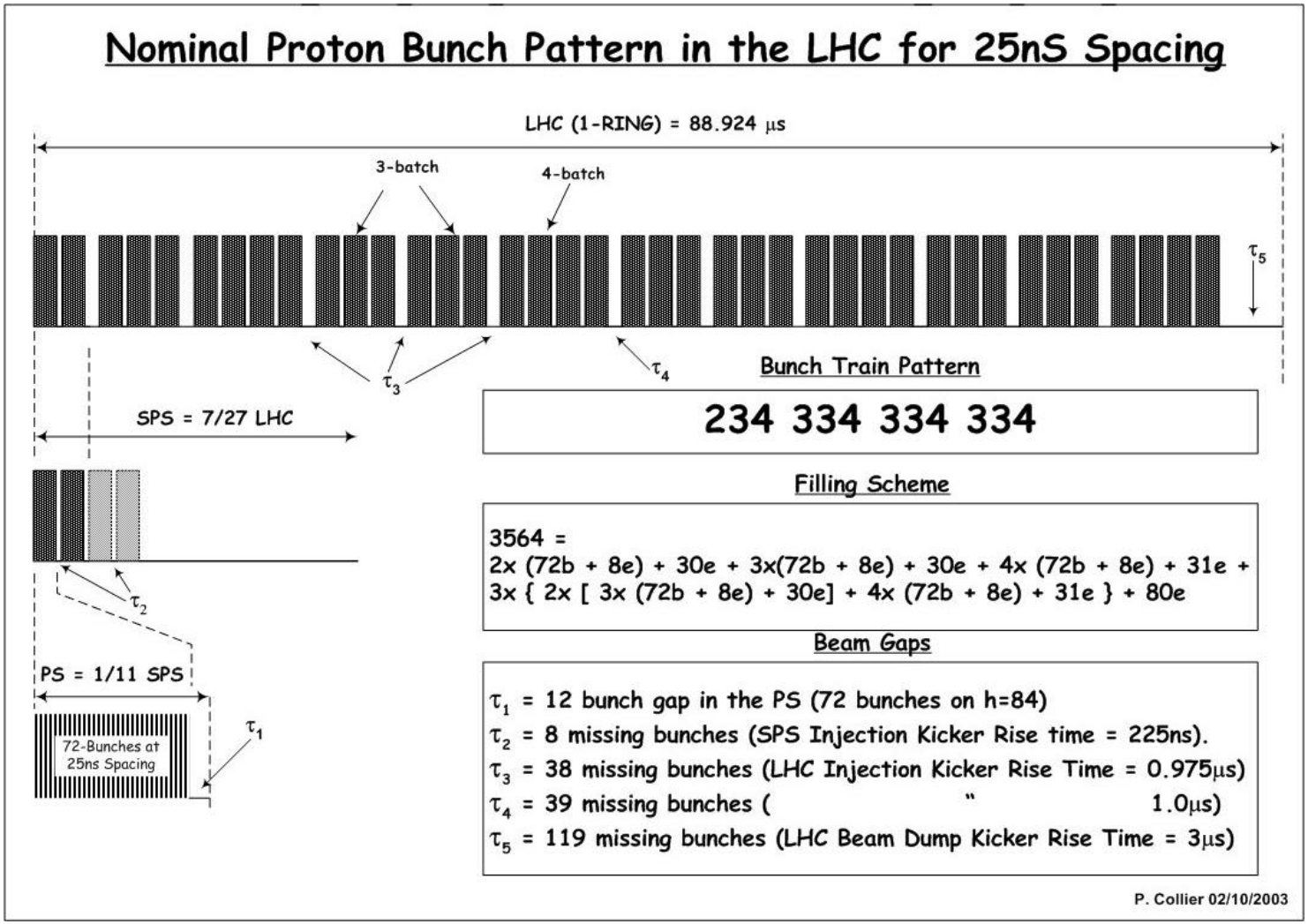


Figure 1: The nominal LHC filling scheme for proton operation

2. General LHC Parameters (2)

- The nominal LHC bunch spacing is 24.95ns, which for the LHC represents a revolution period 88.924μs divided by a possible 3564 slots.
- For proton-proton collisions, a total of 2808 bunches are injected in 12 batches into each ring. Each of these batches will consists of either 2, 3 or 4 PS batches containing 72 bunches. The injection sequence presently foreseen is 234-334-334-334, as shown in figure 1.
- Early LHC operation [1] will be based on the injection, ramp and collision of a single pilot bunches. This will be followed by a first physics run with 43 on 43 bunches equally distributed around the machine.

2. General LHC Parameters (3)

- Single pilot bunch parameters:
- Intensity = 5e9 cpb (charges per bunch)
- Number of bunches = 1
- Bunch spacing = 88.924μs
- Normalised transverse emittance = 3.75um
- RMS bunch length at injection 11.24cm
- Relative rms energy spread at injection 4.72×10^{-4}
- RMS bunch length @7 TeV ? 7.55cm
- Relative rms energy spread @ 7 TeV ? 1.13×10^{-4}

2. General LHC Parameters (4)

- Initial colliding beam parameters:
- Intensity = 3-4e10 cpb
- Number of bunches = 43
- Bunch spacing = ~2μs
- Normalised transverse emittance = 3.75um
- RMS bunch length at injection 11.24cm
- Relative rms energy spread at injection 4.72×10^{-4}
- RMS bunch length at 7 TeV ? 7.55cm
- Relative rms energy spread at 7 TeV ? 1.13×10^{-4}

2. General LHC Parameters (5)

- Ultimate bunch parameters:
- Intensity = 1.67e11
- Number of bunches = 2808
- Bunch spacing = 25ns
- Normalised transverse emittance = 3.75um
- RMS bunch length at injection 11.24cm
- Relative rms energy spread at injection 4.72×10^{-4}
- RMS bunch length at 7 TeV ? 7.55cm
- Relative rms energy spread at 7 TeV ? 1.13×10^{-4}

3. Layout and Infrastructure (1)

- The four Schottky detectors (one per plane per beam) will be installed in Point 4 of the LHC (see appendix A). These will all be located in RA47, with the beta functions for the plane of interest at each detector location between 400 and 470m.
- Beam 1 : H next to Q6R V next to D4R.
- Beam 2 : V next to Q6R H next to D4R.
- The estimated radiation levels at these locations for nominal running are as follows:
- Adjacent to beam pipe = <100Gy per year & <5e11 1MeV neutron equivalent flux (cm-2/year)
- On floor (1m below detector) = <30Gy per year & <1e11 1MeV neutron equivalent flux (cm-2/year)

3. Layout and Infrastructure (2)

- One 44U electronic rack will be available in the service gallery (UA47) for the signal treatment electronics of all four Schottky systems. The distance from the electronic rack to the pick-ups will be between 40m and 60m. Two 3/8” Heliax cable links are currently foreseen between each pick-up and the electronic rack, although waveguide links could be envisaged. Radiation in the service gallery is negligible, but access during beam operation is prohibited.
- The 40 MHz bunch timing and 11 kHz revolution frequency can be made available in the service gallery.
- Four 7/8” Heliax cables, each of approximately 500m in length, are also foreseen to link the electronics rack in the service gallery to a second rack in building SX4 on the surface.

4. Schottky Detector Mechanical Specs (1)

- Detector Geometry:
  - Length: maximum length of 1.5m including flanges and any aperture adaptation inserts.
  - Aperture: minimum aperture of 60mm in both planes simultaneously
  - Inter-axis pipe distance: 194mm
  - Flanges: Conflat DN100 ID80mm
  - Adjacent beam pipe dimensions: ID80mm, OD84mm
  - Taper: 15° adaptation to adjacent chambers

4. Schottky Detector Mechanical Specs (2)

- Each detector should:
  - be constructed for single plane operation
  - be independently moveable by ±4mm in its plane of operation
  - be electrically and mechanically separated
  - use only 316LN stainless steel and copper as metallic constituents.
  - not contain any Teflon or other plastic material (e.g. for isolators or cables)
  - only use low out-gassing ferrite if required for microwave damping
  - be bake-able to the standard LHC temperature of 250°C
  - be able to reach a vacuum of better than 10^{-10} Torr.

5. Schottky Detector Signal Treatment Specs

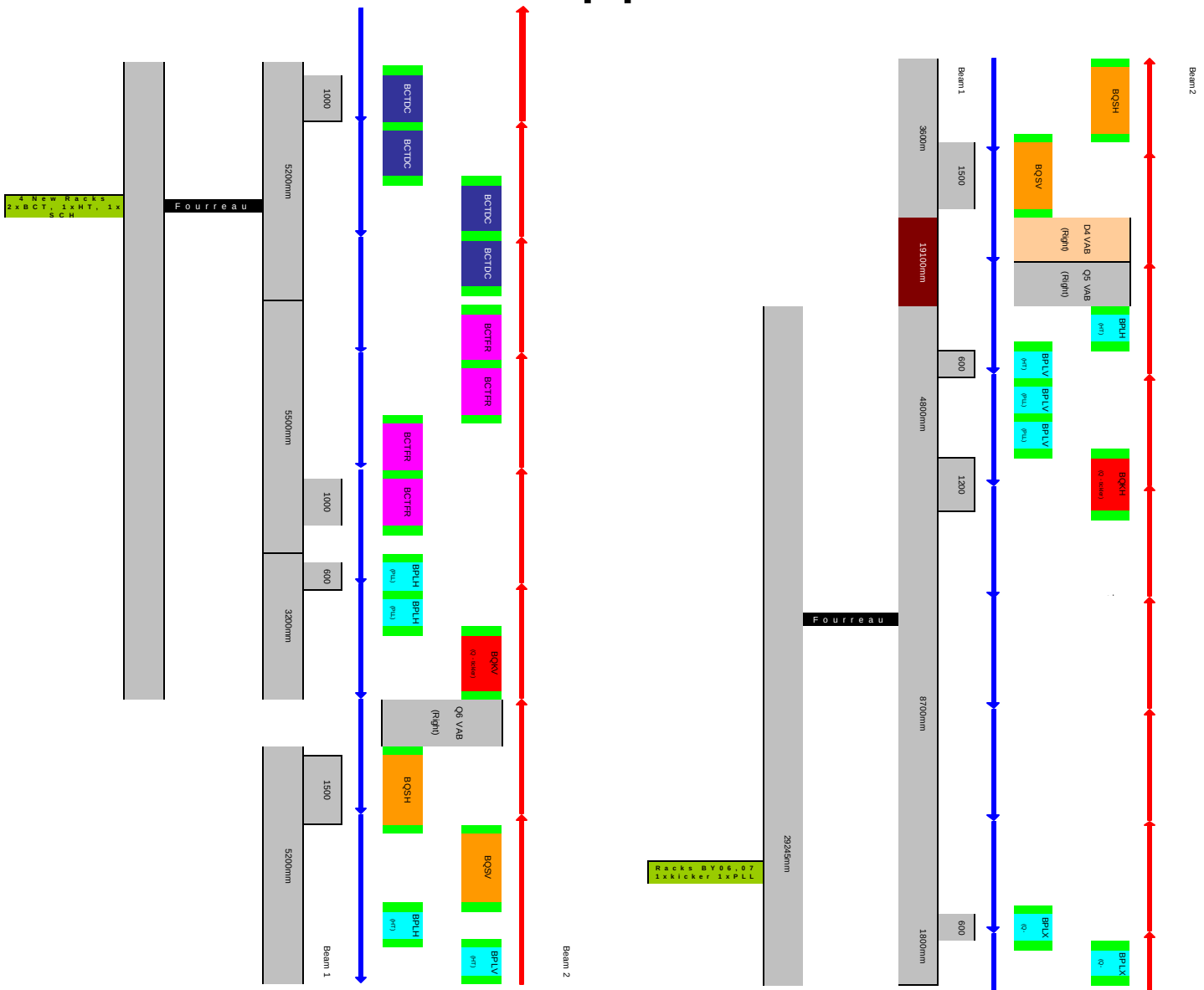
- The detector shall function anywhere between 3GHz and 6GHz. The lower frequency is given by the longitudinal Z/n which shall be <1W for the whole machine, while the upper frequency is determined from the band overlap criterion.
- The possibility of electronic gating shall be foreseen for individual bunches or groups of bunches. Gating timing can be made available from the standard LHC timing module.
- The setting and data acquisition of all Schottky diagnostic related instruments in the service gallery, including the movement of the pick-up, shall be controlled via the Ethernet. Any local front-end computer shall conform to the CERN VME64x standard.

6. Conclusion, Acknowledgements, Refs

- Conclusion:
  - To be found at this workshop (hopefully and with the help from all of you)

- Acknowledgements
  - Without the patient and long lasting help from FNAL and in particular R. Pasquinelli we would not have arrived at this point
  - Many thanks to J.P Koutchouk and G Tranquille for theoretical contributions as well as F.Pedersen, T.Linnecar and H.Schmickler for support.
- References
  - [1] http://abdiv.web.cern.ch/abdiv/Conferences/Chamonix/chamx2005/PAPERS/1_01.pdf

Appendix


Proposed BDI Layout **IR4 - Right**
Beam 2
Beam 1
BQSH
BQSV
D4 VAB (Right)
Q5 VAB (Right)
BPLH
BPLV
BPLX
BQKH
3600m
1500
19100mm
600
4800mm
1200
8700mm
1800mm
Fourreau
29245mm
Racks BY06,07 1xkicker 1xPLL
4 New Racks 2xBCT, 1xHT, 1x SCH
5200mm
1000
5500mm
3200mm
BCTDC
BCTFR
BQKV
Q6 VAB (Right)
Beam 1
Beam 2